

ART. XIX.—*The Sand Ridges, Sand Plains and "Sand Glaciers" at Comet Vale in Sub-arid Western Australia.*¹

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(With Three Text Figures).

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Introduction.

Comet Vale is a mining township 1236 feet above sea level, and 63 miles north of Kalgoorlie, on the railway from Kalgoorlie to Leonora. The district forms part of the great sub-arid plateau in south-central Western Australia, where the rainfall is probably under 10 inches per annum. There is a notable quantity of blown sand in the district, and the distribution of this sand throws considerable light on the action of the wind in the formation of certain types of country.

Summary.

At Comet Vale blown sands are widely distributed and are associated with other types of country, namely, deeply dissected "high" lands, and the "dry" lake or playa, Lake Goongarrie.

The blown sands from sand ridges, sand plains and "sand glaciers." The ridges are mostly parallel to one another and are approximately east and west in general direction. They rest upon the sand plains.

At the township of Comet Vale the sand forms a smooth and unbroken surface with a gentle fall to the west. The sand is wind-borne and has spread steadily up the flanks of a laterite ridge to the east, and in some instances has climbed the passes or saddles of the ridge, thence widening out on the opposite (eastern) side of the ridge as "sand glaciers."

The sands have been derived from extensive sand areas to the west, and are marching eastwards. The dominant winds are apparently westerly.

In its march eastwards, the sand has blotted out the drainage lines west of the laterite ridge; and east of such ridge, the courses of various small intermittent streams from the "high" lands have been diverted.

¹ By permission of the Acting Government Geologist.

The occurrence of a smooth, unbroken, sloping plain of sand, which has been formed by wind action, is important as probably throwing light on the occurrence of sand plains elsewhere in sub-arid Western Australia.

The Chief Physical Features of the District.

(1) To the east of the township there is a belt of "high" lands which has two main divisions, as follow:—(a) A north-north-west-trending belt which has been dissected into various ridges of

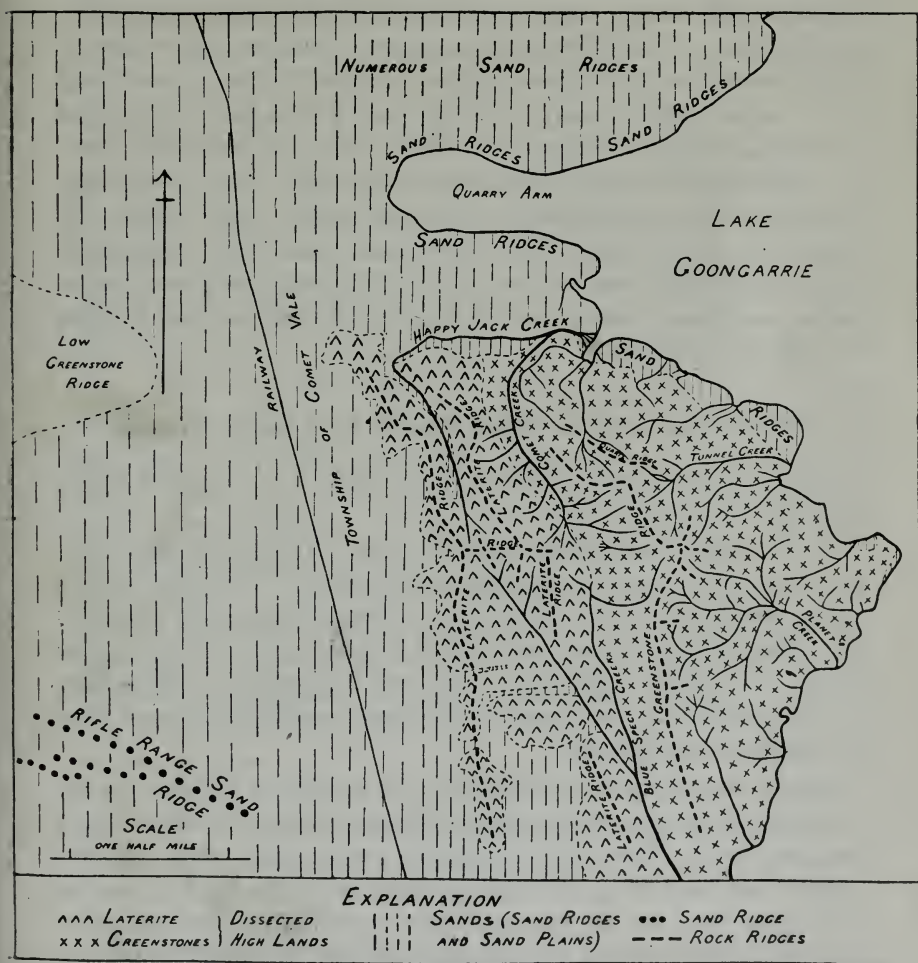


Fig. 1.—Physiographic Map of Comet Vale. Note.—A belt of alluvium occurs along the floor of the Blue Speck Creek valley. This has not been shown on the map.

ferruginous laterite, the chief of which is a ridge bearing north-north-west on the western side of the belt. The latter is separated on the east from the area now to be described by a deep, but mostly wide, open valley. (b) A belt of greenstone lying to the east of (a) and bounded on the east by the "dry" lake or playa, Lake Goongarrie. This belt is deeply dissected by narrow V-shaped radial valleys in the adolescent or early mature stage. The crests of (a) and (b) are about 100 feet above the floor of the lake.

(2) Lake Goongarrie forms an extensive "dry" lake or playa having on its western shore greenstone cliffs which form part of (b), and having on its northern and north-eastern shores sand ridges.

(3) Gently undulating sand plains lie to the west, north and north-west of the township, and on these plains rest sand ridges of varying height (the highest probably being 50 or 60 feet above the plains) and having an approximately east and west trend. The sand plains are broken by occasional small "dry" lakes. No watercourses exist in this belt, as the sand immediately absorbs the rain. Just to the east of the railway the sand overlies a rather coarse ironstone "wash," a few feet thick, which in turn overlies the bedrock, greenstone.

Vegetation of the Sand Plains and Sand Ridges.

Slight differences exist between the vegetation of the sand plains and that of the sand ridges.

On the sand plains there are two types, which may be termed the acacia type and the eucalyptus-"spinifex" type, the acacias or the eucalyptus and "spinifex" predominating as the case may be. The eucalypts are of the stunted branching-from-the-root type known as "mallee" eucalypts. The two types may in places more or less merge into one another, but over considerable areas they are substantially distinct.

On the sand ridges the vegetation can hardly be divided for the purposes of this paper into distinct types, but some characteristics may be noted. The mallee eucalypts grow on the sides of some ridges, but usually cease before the top is reached. The acacias may grow both on the top and sides, and likewise the spinifex; but as a rule spinifex and acacias are not commonly found together. The tops of the ridges may be destitute of tall shrubs and trees, and in this case the spinifex usually grows, associated with low, often sprawling shrubs.

The vegetation as a whole is stunted and xerophytic, and there is much bare ground between the plants.

Nature and Distribution of the Blown Sands.

The blown sands of the district may be divided into (a) sand plains, (b) sand ridges or dunes, and (c) "sand glaciers."

(a) The *sand plains* cover large areas to the west and to the south of Comet Vale. They may be almost level or undulating. The township of Comet Vale is largely built upon a sand plain which slopes gently downward with a smooth and unbroken surface to the west from the western flanks of the north-north-west trending laterite ridge immediately to the east of the township. The sands of the sand plains are generally fine-grained and consist mostly of quartz. They contain a certain amount of fine material which tends to make the surface somewhat firm. The surface is thus composed in places of what might be termed a loamy sand.

(b) The *sand ridges or dunes* are numerous, and occupy considerable space to the west and to the north of Comet Vale. A prominent ridge, which the writer has named the Rifle Range Ridge, lies to the south-west of the town; and on both the northern and southern sides of the Quarry Arm of Lake Goongarrie, steep ridges rise from the edge of the lake. For about four miles northwards from the township the railway cuts through many.

The ridges have sides varying in slope from steep to gentle, and rise from the sand plain to a maximum height of about 50 or 60 feet.¹ They are roughly parallel to one another and have a general east and west trend, with variations towards west-north-west and towards east-north-east. If the westerly winds be the dominant ones, as they appear to be, the ridges are longitudinal.

The ridges vary in their distances apart, some being practically isolated, and others within a quarter of a mile of one another. Some reach a length of over half a mile. Fine well-rounded grains of quartz and ironstone, the quartz predominating, form the sands of the ridges, and the surface layers at least seem to be free from the finer material, which no doubt has been blown or washed out from the sand. Between the ridges the sand is mixed with finer material, as already mentioned when describing the sand plains.

Some of the ridges are compound ones, being forked, with two or more branches. The Rifle Range Sand Ridge towards its western

¹ Some elevated irregularly shaped areas of blown sand have long gentle slopes and, in some cases, flat tops. They are apparently due to some local phase of wind action, but they are not further discussed in this paper.

end breaks into three branches which are separated by troughs a comparatively few feet deep. The bottoms of these troughs are well above the surrounding sand plains, so that they are part of the ridge. Between two of these branches there is a distinct roughly circular basin in the sand having a diameter of about 30 or 40 yards and a depth below the rim of perhaps 25 feet. This is the type described by Cornish¹ as a fulj.

(c) The typical forms of sand accumulation known as "*sand glaciers*," which have been described in various parts of the world are due to sand being blown up the sides of hills or mountains, thence finding a passage through any passes or saddles, and spreading out on the opposite sides to form wide fan-shaped plains. This is Free's definition.² Cornish³ restricts the term to a horizontal plateau of sand terminated by a talus, as steep as the sand can rest. The forms at Comet Vale are, on a small scale, closely related to those referred to by Free; hence the present writer retains the term as a convenient one.

Immediately to the east of the town is a north-north-west trending ridge of laterite forming part of the laterite high lands previously referred to. This ridge is cut into by amphitheatres, which form the heads of the small watercourses which formerly extended westward; and it also has several comparatively low passes or saddles. The lower western flanks of the ridge have a smooth unbroken sloping sand plain with a gentle but still a definite fall to the west. Artificial openings, such as mining shafts and costeans, show that the sand of this plain is here from a few inches to about ten feet in depth, and that it is fine-grained, well-rounded and homogeneous. It shows, however, no planes of stratification, but would probably do so if it became consolidated and subsequently weathered out. Below the sand there is a deposit from one to six feet thick, made up largely of angular fragments, up to three or four inches in size, of laterite, similar to that of the laterite ridge referred to above. This material is evidently derived from such ridge and represents the debris spread over the surface before the sand drifted up the slope, the carrying of such rock waste no doubt being due to the occasional tiny streams which ran from the amphitheatres above described, and to the fact that such waste always tends to drift by gravitation from higher to lower slopes.

1 Cornish, V.—"On the Formation of Sand Dunes." *Geog. Journ.*, 1897, pp. 295-298.

2 Free, E. E.—"The Movement of Soil Material by the Wind." U.S. Dept. of Agric., Bureau of Soils, Bull. No. 63, Washington, 1911, p. 57. (Footnote a).

3 *Op. cit.*, p. 286.

Below this laterite waste, the bedrock of greenstone (a fine-grained epidiorite or amphibolite) occurs. The sand can be traced to some of the saddles of the ridge, through which it has passed, and spread itself outward and downward on the eastern sides of the ridge. Towards the northern end, the sand on one saddle has become discontinuous, by erosion of some kind, with that lower down on the eastern slope of the ridge, where it is now being removed by stream action. Towards the southern end, at another saddle, a small amount of sand has spread well over the saddle, but has not, as a blown sheet, reached far down the eastern slope, as it is being carried away by a small watercourse, along which it forms a narrow thread. Still farther south the sand has spread out as a wide, long mass and has merged into that which has worked around the eastern side of the ridge from the sand plain to the south of this ridge. Stream action has carried portions of this sand farther east as narrow bands. Where the ridge is higher than the passes, the sand flanking the ridge on its western side is at a lower level than that at the passes. The outline of the sand at its junction with the laterite thus shows a series of curves rising in height as the passes are approached.

These deposits of sand, which are clearly wind-blown, constitute, on the eastern side of the laterite ridge, the "sand glaciers" of Comet Vale, and this paper is, so far the writer is aware, the first record for such phenomena in Western Australia.

Generalised Sections

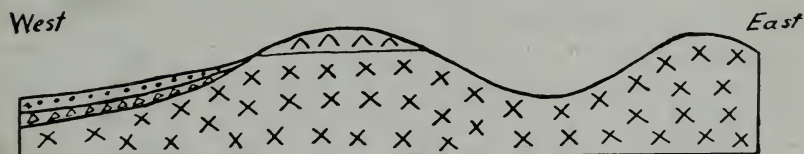


Fig. 2 Through a crest of the main laterite ridge.

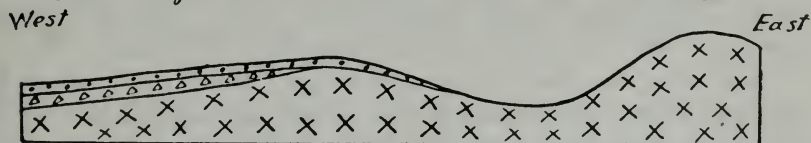


Fig. 3 Through a pass on the main laterite ridge

△△ Laterite cap XX Greenstones
 :: Blown Sands △△ Laterite Wash.

Figs. 2 and 3.—Generalised sections across the sloping sand plain and the dissected high lands, showing the relation of the sand to the crests and passes of the main (western) laterite ridge.

Effects of the Sand on the Topography.

The effect of the spread of the sands has been to divert some of the present small stream courses at Comet Vale and to blot out the drainage to the west of the same place, as there is evidence of a wide north-south valley there, which must have been a drainage line before the sands spread across and choked it. The water courses which originally ran westward to this old valley from the laterite ridge have also been smothered. The general result is the substitution of the sand ridges and sand plains for the old fluvatile topography.

Significance of the Sand Distribution as to the Work of the Wind in this and other Areas

The numerous sand ridges of the district show that the wind has removed a very large quantity of sand, and hence its influence on the general erosion of this portion of the country must be considerable.

The most important sand distribution of the district, however, is the belt of sand on which the township of Comet Vale stands. This has already been described as a gently-sloping sand plain on the western flanks of the laterite ridge, and falling westwards. This sand belt, as also shown above, passes over the saddles of the ridge and then into the "sand glaciers." The sand on the western flanks of the ridge is wind-blown beyond question. There are no rocks at the ridge or thereabouts that could have provided the material; the sands, as seen in artificial sections, are remarkably homogeneous in texture and materials; the waste from the laterite ridge lies buried beneath the sands; and the sands are continuous with the wide sand area to the west. These facts, together with the distribution of the sand up the flanks of the hills, through the passes and thence on the opposite side of the ridge as "sand glaciers," leave no doubt as to the wind origin of the sand.

That being so, there exists a sand slope, smooth and unbroken by sand ridges, and to all intents a sand plain; and this sand plain has been formed by the wind. Sand plains are of wide occurrence in inland Western Australia, and although the wind was thought to be an important agent in their formation, direct evidence as to its action is not always obtainable. The Comet Vale evidence may help to determine the matter, although of course each area must be independently investigated. It, however, suggests

that many of the other sand plains of inland Western Australia may be at least partly of wind origin.

A somewhat parallel case occurs at Goongarrie, a mining township 8 miles to the south of Comet Vale. The township is situated on an unsymmetrical ridge the western side of which has a gentle unbroken slope, but the eastern side is represented by a line of low cliffs cut into small canyons by the short watercourses (almost always dry) which trend eastward to a small southward-trending valley. The rocks of the ridge are serpentines and hornblendites, but the western slope is covered (only, however, to a depth of about six inches) by fine quartz sand of the origin of which no other explanation can apparently be given than that it has been blown by the wind from the west up the slope. There are greenstone hills a little farther west, and beyond these extensive sand plains. The sand could be, and probably has been, blown from the sand plains through a gap in the greenstone hills opposite to the unsymmetrical ridge now referred to. An interesting point is that portions of the sand on the western slope have been blown over the crest of the ridge into the heads of the eastward-trending watercourses above described, and that stream action is carrying it to the lower portions of the valleys. Wind action on the western slope has probably been accelerated by the removal of a considerable portion of the native vegetation.

An unbroken sloping plain of wind-blown sand remarkably parallel in certain points to the Comet Vale and Goongarrie examples, although on a much greater scale, has been described by Ball¹ in West-Central Sinai. The plain of Debbet el Qeri rises gradually to the south, due to the prevalent northerly winds carrying the sand along, with a gradual overflow into the heads of the deeply-cut wadis draining southwards; the present tendency of the sand is to move southwards and choke the heads of the wadis. The sand is covered with scattered bushes, and its surface was level enough to be used for the base line of Ball's triangulation.

Direction of Past and Present Drift of the Sands.

The distribution of the blown sands suggests that they have drifted easterly and that the dominant winds therefore have been from the west. From limited observations made by the writer in

¹ Ball, J.—“The Geography and Geology of West-Central Sinai.” Survey Department, Cairo, Government Press, 1916, pp. 87-88, 115.

the Comet Vale district in the summer of 1916-1917, and the early part of the winter of 1917, the present dominant winds also appear to be westerly, and this is confirmed by observation of blown sand in regard to the so-called "spinifex" plant, the direction of inclination of certain trees, and the movement of the sand along the railway line where the removal of the vegetation has allowed the sand to move more rapidly than it otherwise would do.
